SCIENCE

A WEEKLY RECORD OF SCIENTIFIC PROGRESS.

ILLUSTRATED.

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To Correspondents.

All communications should be addressed to the Editor—box 3838, P. O., New York—with name and address of writer, not necessarily for publication without consent.

Scientific papers and correspondence intended for publication should be written *legibly* on one side only of the paper. Articles thus received will be returned when found unsuitable for the Journal.

Those engaged in Scientific Research are invited to make this Journal the medium of recording their work, and facilities will be extended to those desirous of publishing original communications possessing merit.

Proceedings of Scientific Societies will be recorded, but the abstracts furnished must be signed by the Secretaries.

Both questions and answers in "Notes and Queries" should be made as brief as possible; an answer appearing to demand an elaborate reply may be written in the form of an article.

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SATURDAY, JANUARY 22, 1881.

Lieutenant Schwatka still remains a prisoner in his quarters on Governor's Island in New York harbor, in consequence of his recent accident. Surrounded by many of the trophies of his arctic experiences, he relieves the monotony of his situation by preparing for the press his forthcoming history of the expedition, with which his name must be forever associated.

Any reference to arctic expeditions at this moment naturally recalls to mind the fact, that a brave American officer and his crew are now locked in the firm embraces of the frozen solitudes of that desolate region, heroically struggling to accomplish a service to humanity.

The gallant De Long may be safe in winter quarters with the Jeannette, waiting for the moment when a channel may be opened for his ship's return; but all past experiences in the polar regions suggest that none but the over-sanguine should rely on such a fortunate conclusion of the voyage, and the common instincts of humanity demand that a relief expedition be immediately organized, to sail at the earliest possible moment to carry succor to De Long and his party, and to report on his condition.

There are other reasons for immediately sending aid to the Jeannette; the attempt to reach the North Pole entails a colossal task, and it is perhaps vain to expect any expedition to reach it by a sudden and unexpected stroke of success; probably nearly four hundred miles of sleigh travelling over rugged and almost impassable hummocks of ice will have to be accomplished at an average speed of six to eight miles a day; this would occupy fifty consecutive days, and then, if all went well, would come the return journey with equal dangers and difficulties. Captain Nares pronounced such travelling impossible.

Lieutenant Schwatka has, however, shown that with better organization and different methods, the dangers of a sleigh expedition can be much reduced. Unfortunately, De Long has not the benefit of "Schwatka's" experiences, and has probably, like "Nares," harnessed his men to the sleigh and not depended upon dogs to drag it over so many tedious miles of dreary wastes. It would, therefore, appear obvious that even should the Jeannette expedition be actually safe and intact, the arrival of new supplies and general aid at the side of DeLong would be most opportune, and may even lead to accomplishing the great object in view.

Possibly some of our readers may consider that the time for sending a relief expedition to the Jeannette has not arrived, and that it may be prudent to await tidings of disaster before help is sent. We have somewhat anticipated such reasoning, but would add that the consequences of such a course in the case of the lost Franklin Expedition led to a final outlay of $10,000,000 by the English nation withnegative results.

We now know that had a relief expedition been sent immediately to the rescue of Franklin, the brave officers and crew might have been easily saved.

Lieutenant Schwatka strongly urges the necessity of sending immediate relief to the Jeannette expedition, and at our request will state in our next issue some of the reasons which lead him to that conclusion. No names have been so far mentioned to take a part in this undertaking, but we trust the services of Lieutenant Schwatka may be secured, as his past experience and great success would give us hope of the best results being accomplished.

The excellent work accomplished by Lieutenant Schwatka, an officer of the United States Army, in arctic explorations, would appear to teach us one lesson, that too great reliance on Naval men reaching the North Pole unaided should not be entertained. Sailors proverbially stick to their ships, are out of their element on shore, and appear unable to cope with difficulties when away from the base of their supplies. Compare the sleigh expeditions of Nares and Schwatka, and note how differently they were managed, the former starting without necessary material, making his men beasts of burden, and failing miserably from the collapse of all his resources.

Schwatka, on the contrary, so contrived that the necessaries of life were always available. Forty dogs merrily drew his sleigh, and with the instincts of a military man he carefully husbanded his resources, and accomplished sufficient to make his expedition a memorable success.

It seems on this account possible that the two arms of the service may profitably combine in the next effort to solve the great Polar problem, for the best results may be anticipated by such united action.

Mr. H. H. Warner, of Rochester, N. Y., offers a prize of $200 in gold for the discovery of any comet during this year. The conditions are that the comet must be unexpected and telescopic, excepting the comet of 1812, and the first discovery must be made in the United States or Canada, and immediate notification telegraphed to Professor Lewis Swift, of Rochester.

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This Society now numbers one hundred and nineteen active members, and is stated to be in a flourishing condition. We trust we may occasionally hear from the Society, and that the record presented in our columns may show that a real advance in microscopical studies has been accomplished.

ELECTRIC FISH.*

By the Marchioness Clara Lanza.

The science of electricity and magnetism is clearly acknowledged to be an acquisition belonging to modern times, we might say to the last century. To the ancients this great world of ideas was completely unknown, with the exception of a few individual facts which must have appeared to them in a very puzzling light, as philosophy and physics were in a wholly powerless and perplexed condition.

If we pass over the electric phenomena of our own atmosphere, thunder and lightning, the only facts concerning electricity known to the ancients were the capacity of the magnet to attract iron, the attractive power arising between two pieces of amber when rubbed together, and the peculiar effects exhibited by electric fish.

One of the most numerous and common fish found in the Mediterranean Sea is the torpedo, which is able to eject electric shocks of such force that a man's arm has often been lamed by them. The knowledge of this fact can be traced back to the farthest antiquity. These fish are so often seen on the coasts of Italy and Greece that the effects produced by them must have led to the first experiments, made, in all probability, by fishermen and people directly inhabiting the coasts of these countries; at all events, the knowledge of this fact is much older than that relating to the magnet and amber, which certainly extends to a remote pre-historic period.

The Greek designation of these words, magnet and amber, contains no etymological relations to the qualities peculiar to these bodies, which must have appeared so mysterious to the ancients. The Greek term for magnet, *Heraklea* and *Magnetis*, denotes simply a stone found in the City of Heraklea or Magnesia—while the Greek word for amber, *Electron*, relates merely to the color of the substance. In this way it is evident that both the magnet and amber were long known to the Greeks and named by them before their peculiar physical properties were ascertained.

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Perhaps of no more recent date is the practical and most interesting use which the inhabitants of the Mediterranean countries made of the torpedo's electric capacity, thus undoubtedly representing the beginning of electro-therapeutics. As a certain cure for headache one or more living torpedos placed upon the affected part was strongly recommended—just as at the present time a constant galvanic current is used as the most reliable manner of curing the same complaint.

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If we pass over the electric phenomena of our own atmosphere, thunder and lightning, the only facts concerning electricity known to the ancients were the capacity of the magnet to attract iron, the attractive power arising between two pieces of amber when rubbed together, and the peculiar effects exhibited by electric fish.

One of the most numerous and common fish found in the Mediterranean Sea is the torpedo, which is able to eject electric shocks of such force that a man's arm has often been lamed by them. The knowledge of this fact can be traced back to the farthest antiquity. These fish are so often seen on the coasts of Italy and Greece that the effects produced by them must have led to the first experiments, made, in all probability, by fishermen and people directly inhabiting the coasts of these countries; at all events, the knowledge of this fact is much older than that relating to the magnet and amber, which certainly extends to a remote pre-historic period.

The Greek designation of these words, magnet and amber, contains no etymological relations to the qualities peculiar to these bodies, which must have appeared so mysterious to the ancients. The Greek term for magnet, *Heraklea* and *Magnetis*, denotes simply a stone found in the City of Heraklea or Magnesia—while the Greek word for amber, *Electron*, relates merely to the color of the substance. In this way it is evident that both the magnet and amber were long known to the Greeks and named by them before their peculiar physical properties were ascertained.

With the torpedo it is different. The ancient Greeks called it *Marke*, and the verb derived from this substantive signifies to stun. In the same way the Latin name, *Torpedo*, denotes something which produces numbness and lameness. In the fish markets of Marseilles and Toulon, the torpedo is called *torpille*, and thus the word torpeur, (derived from the Latin *torpor*), is used in French to denote numbness and stupefaction. The Italian fishermen call it *Tremola* on account of the characteristic trembling sensation which its touch produces. In the Arabic *patois* of the Maltese, *Haddaila* is the name applied to an electric fish.[1] Thus we find that everywhere the name of the torpedo is etymologically allied to its electric capacity, which makes it evident that the knowledge of its peculiarities extends to the most distant period in the construction of language.

Perhaps of no more recent date is the practical and most interesting use which the inhabitants of the Mediterranean countries made of the torpedo's electric capacity, thus undoubtedly representing the beginning of electro-therapeutics. As a certain cure for headache one or more living torpedos placed upon the affected part was strongly recommended—just as at the present time a constant galvanic current is used as the most reliable manner of curing the same complaint.

Aside from this, the numerous passages in the Greek and Roman authors which relate to the torpedo and its effects are mostly of a subordinate interest. Their language, like ours, struggles to express that numb and trembling sensation occasioned by the electricity proceeding from the fish, and which we ourselves are unable to describe and simply designate by the name of "electric

* Translated for "SCIENCE" from the German of Prof. Franz Boll.

1 John Davey, *Anatomical and Physiological Researches.* London, 1839. Vol. I.

shock." We are informed that the fish makes use of this power to defend itself against its enemies, and also as an offensive weapon towards its victims. This means of defense, however, does not only take effect in consequence of immediate contact, but likewise when the fish is quite removed from all association with any object. It is well known that the shock has been clearly felt, as if by close contact, (harpoons, etc.), by fishermen who drew towards land a net in which was found a torpedo. When a stream of water was poured from a vessel upon the fish, the men's hands were powerfully affected, just as the frightful, stunning sensation is conveyed to the unsuspecting angler through the medium of his fishing line.

It is greatly to be regretted that the most celebrated natural investigator of antiquity did not turn his attention to torpedoes. Among the writings which are attributed to Aristotle only very brief mention is made of this extraordinary creature. This is the more to be wondered at inasmuch as Aristotle speaks of the torpedo in reference to something else, and appears to have a complete knowledge of its anatomy. He, therefore, knew that it belongs to a viviparous species, a fact which, in our own time, has been disputed by Cuvier.

Aristotle having failed to give any explanation of the torpedo, it is, perhaps, not astonishing that the rest of antiquity did not enter upon the subject. Indeed, among all the writings of the ancients which treat of the torpedo, there cannot be discovered the slightest attempt to throw any light upon this wonderful phenomenon and reduce it to purely natural causes. The best and most intellectual article found among ancient writings in regard to this point is from the pen of the Greek physician, Galenus, who lived in Rome about 200 years after Christ. He compares the effects of the torpedo to the working of the magnet.[2]

Besides the torpedo there is another electric fish belonging to the realm of antiquity, and in exact opposition to the former, a fresh water fish. In reality, in all the rivers of Africa, especially the Nile and its neighboring streams, from mouth to source, one of the most common fish to be met with is the *Malopternus electricus*, the electric Silurus. In size and electric power this fish is almost equal to the torpedo, but in other respects it is totally unlike the wonderful salt water creature. It is exceedingly interesting to observe that in this fish the same etymological relations and the same remedial representations in regard to nervous maladies, are found as in the torpedo. Unfortunately we are not acquainted with the name applied to it by the old Egyptians, nevertheless, we know that from the invasion of 638, which laid the foundation of the Arabian language and culture to the present day, the fish has been called *raâdah* or electric fish. The Jesuit Godigno, who in the sixteenth century undertook a journey to Abyssinia, tells us that the Ethiopians made use of this fish for the purpose of "casting out devils," or in other words to cure nervous diseases.

A passage in Athenæus where the *Marhe* is represented among the Nile fish proves that the Greeks were aware that electric fish were found there. Yet, the electric Nile fish appears to have been unintentionally identified by them with the Mediterranean torpedo, as mistakes and misconceptions concerning them extend far into the past century.

Abd-Allatif, a physician of Bagdad who lived in the twelfth century, writes as follows in his history of Egypt: "Among the animals peculiar to Egypt, we should not forget the fish called *raâdah* for the simple reason that while it lives no one can touch it without experiencing an irresistible trembling sensation. This impression is accompanied by cold, numbness, a crawling feeling and lameness in the limbs, so that it is impossible for one to remain in an upright position or hold anything. This extraordinary stupefaction extends through the arm, the shoulder and entire side, however superficial and light the contact with the fish may have been. A fisherman assured me that when such a fish is caught in a net, the effect produced is distinctly felt by the man, although his hand does not touch the fish, and even remains some distance from it. When dead the *raâdah* loses this power. People accustomed to bathe in water where this fish is found say that the mere breath (?) of the *raâdah* is sufficient to produce such numbness of the body that the person affected can scarcely keep from sinking." [3]

We see that the knowledge of Arabian physicians concerning the Malopternus amounts to about the same thing as that obtained by the Greek and Roman authors in regard to the torpedo, and in both cases we are unable to discover the slightest trace of any inclination to analyse the mysterious effects of the fish.

Four hundred years later than the celebrated Arabian physician, the Jesuit Godigno, journeyed on the Nile. He speaks of the electric silurus in exactly the same terms as his predecessors, and it would be useless to mention it here in any special way, if his travels did not refer for the first time to a fact, which as an unconscious example in the study of animal electricity, deserves a place in the history of science. Godigno says:

"The Ethiopians assert (I myself have never witnessed the fact) that if a living electric fish is placed upon a heap of dead fish and allowed to move among them, the fish thus brought in contact with it are seized with an inward and inexplicable trembling to such an extent that they actually appear to be alive. The cause," he continues, "may be authenticated by those who investigate the nature of things in general, and I leave it to them to decide as to what this force of motion communicated by the electric fish to the dead ones may be."

The next author upon this theme, Francesco Redi, distinguished alike as physician, natural investigator and poet, gloriously opens the path for earnest and systematic research.

The beginning of this new era in the history of electric fish can be ascertained even to the day and hour. On the 14th of March, 1666, a freshly caught torpedo was brought to Redi, and to the examination and dissection of this one specimen we owe his masterly physiological and anatomical description of the torpedo, which no anatomist can read without the utmost admiration, and which casts the collected wisdom of antiquity into complete shade.

The most important advancement attributed to Redi, is the discovery of peculiar symmetrical organs situated on each side of the torpedo's head. To-day they go by the name of "electric organs," although the discoverer called them falciform muscles or bodies, and they were known to anatomists as such for more than a century. "It seemed to me," said Redi, in relating his experiments, "as if the painful sensations caused by the torpedo had their origin in these two falciform muscles more than in any other place." Thus the first hints were given towards the correct understanding of the fish, and the inexplicable strength of its electric power pointed out together with its peculiar organs.

Redi's suppositions were soon proved to a certainty by Lorenzini, one of his pupils, who in the year 1678 published an anatomy of the torpedo. From that period until the present day, the study of electric fish has always taken the anatomy, physiology and physics of the falciform organs for its subject, and by this means has been able to obtain deeper and more extensive knowledge. Now the torpedo is no very mysterious object, but at the same time the following question remains more or less open to discussion: How is this wonderful electric organ made, and how is the creature able to produce such extraordinary effects by means of it?

2 *Galeni opera ed. Kuehn.*—Vol. VIII., p. 421.

3 Relation d'Egypte, par Abd-Allatif, médecin Arabe de Bagdad. Traduction de M. Silvestre de Sacy, Paris, 1810.

The first attempts at solution given in regard to this inquiry were of a singularly mistaken character. It has already been said that Redi designated the electric organs as falciform muscles or bodies. This unintentional comparison of the electric organs with muscles has played an important, though by no means wholesome, part in the history of electric fish.

With that broad comprehension, that massive reproduction which subordinate intellects often accord to the master's ideas, Redi's direct successor and pupil, Lorenzini, plainly indicated the electric organs as "falciform muscles," thus entirely overlooking his teacher's apt precaution on this point. And from Lorenzini every anatomist of the following century calls these organs distinctly, and unalterably muscles, although this appellation is completely voluntary, and notwithstanding the fact that the electric organs, outwardly as well as inwardly, are totally unlike muscles of any kind.

If these organs, however, *were* muscles, it was but natural that effects analogous with those produced by muscles should be ascribed to them. There followed, consequently, a purely mechanical theory respecting the action of the organs, which was best set forth by Borelli, in 1685. His opinion was that they contracted several times in quick succession, thus giving a number of violent repulsions to the object brought in contact. This, he thought, was followed by a cramp or spasm of the same nature as that experienced by a person who strikes his elbow sharply. This theory met with universal applause. The most prominent natural investigators, Linné, Réaumur and Hallere agreed perfectly with Borelli, and we may say that until the year 1750 the idea was recognized everywhere as the only possible and complete explanation ever given.

From the time of Redi to Réaumur the investigators limited their experiments to the electric fish most accessible to them—the torpedo. The electric silurus of Africa is scarcely mentioned, and if spoken of at all, it is merely to mistake it for, or identify it with, the torpedo. However, during this period the third and last known electric fish was discovered—the electric eel (*gymnotus electricus*)—found in South American rivers, and possessing the greatest bodily dimensions and the most powerful electric properties of any.

The first news of the gymnotus reached Europe about the year 1672. Later, Alexander von Humboldt made the fish famous, by describing in his book of travels, its fierce struggles with horses. Humboldt tells us that the name "Arimua," given to the eel by the South American Indians, denotes a creature that deprives of motion. He also states that in former times the gymnotus was used as a cure for paralysis. We may judge of the tremendous violence of the eel's electric discharges by quoting a fact related by Humboldt.

"On one occasion the inhabitants of a certain town were obliged to turn a street in an opposite direction because the electric eels had increased to such an extent in the rivers that every year they killed quantities of mules which were accustomed to wade through the water heavily laden.".

However, before more complete information concerning the gymnotus could reach Europe, the youthful study of electricity had undergone an important modification which was destined to bear direct influence upon the theory regarding electric fish. The discovery of the Leyden jar (1745), spread through the world, and attracted universal attention. Experiments were made in all parts of the country, and everyone was anxious to learn the effects of this new natural force by his own experience and sensations.

Under these circumstances, it is not surprising that Adamson, who had studied the effects of the Leyden jar in Paris, on becoming acquainted with the electric eel in Senegal (1751), compared the latter with the former, and remarked that the shocks could be communicated like electricity through an iron wire. Dutch investigators state the same thing in regard to the gymnotus. Its electric shocks can be conducted through a chain composed of several persons, but it is maintained that only the electric conductors transmit the shock, while insulators can touch the fish without any effect being perceived.

Nevertheless, serious doubts arose concerning the correctness of this new theory, until the year 1772, when John Walsh, an Englishman, irrefragably demonstrated the electric nature of the torpedo in a series of experiments given at La Rochelle, the old Huguenot town, in the house of Marie Seignette, the discoverer of Seignette salt. He showed simultaneously that the moment the shock occurs the back and stomach of the torpedo are differently situated in regard to the electricity. Walsh considers the "falciform muscles" as mere electric machines that are put in motion at the will of the animal. Soon afterward this old term disappeared from science altogether, and the more appropriate appellation of electric organs was bestowed in its stead. A few years later, this same Walsh undertook to make a series of experiments upon the gymnotus, several living specimens having been brought to London at his request. The conformity of the shocks was perfectly demonstrated by an electric discharge; indeed, Walsh even succeeded in causing the gymnotus to emit distinct electric sparks. Cotemporary with these experiments by Walsh, the correctness of his theory was demonstrated in another interesting manner. The eminent natural philosopher, Cavendish, sunk under water a wooden board covered on each side with tin foil, and succeeded in imitating the electric phenomena of the torpedo as demonstrated by Walsh, by simply connecting the two sides of the board with a Leyden battery. He thus showed the curved current of the water, which completely agreed with that produced by the electricity of the torpedo. Finally he demonstrated the fact that a hand thrust into the water, although not coming in contact with the fish, must yet be affected by the electric shock proceeding from it in proportion to the distance.

Investigators received a fresh impulse through the discovery of galvanic electricity and electro-magnetism. It remained to be shown, however, that the electricity produced by the fish really possessed all the distinguishing features of galvanic electricity. Alexander Bolta planned numerous experiments, which, unfortunately, were never put into execution. At the instigation of the celebrated chemist, Sir Humphrey Davy, however, one of his brothers, John Davy, performed extensive experiments in Malta upon the torpedo. He observed the diversion of the multiplicator, the magnetizing of a steel rod, visible sparks, decomposition of water and nitric acid, the reduction of iodine from iodide of potassium, and, in short, the complete register from a galvanic current to the production of physical effects. He also maintained, in regard to the direction of the galvanic current, as observed in the torpedo, that at the time of the shock the creature's back is positively situated the same as the stomach. It is to the efforts made by the first natural philosophers, Faraday, Schoenbein, Colladon, E. du Bois-Reymond, and others, that science owes the explanations given in regard to the two other electric fish, the gymnotus and the silurus. It has been ascertained that the current in the former flows from head to tail, while in the latter it takes an exactly opposite direction.

Anatomists were no less prompt by exploring the construction of the electric organs than natural philosophers were the physics. The most distinguished names in anatomical science consecrated themselves, so to speak, to this particular theme. An account of these investigations can be read in the works of John Hunter, Etienne Geoffroy, St. Hilaire, Pacini, and Max Schultze. The descriptions of the torpedo and silurus written by Paolo Savi and Th. Bilharv are masterpieces of anatomical research. Unfortunately, we are still without a like description of the gymnotus.

In order to obtain a thorough comprehension of the electric organs and their action, it is necessary to have re-

course to a third science, experimental physiology, to unite anatomy with natural philosophy, and thus make the result of one answer for the other. Whoever wishes to acquire a clear idea of the three electric fish and their organs must moreover keep the following points always uppermost in his mind:

The electric fish already mentioned as representing three different species are by no means individual fish as may, perhaps, be supposed. On the contrary, they are in form very similar to those belonging to the same families. For instance, the electric eel resembles, to an extreme degree, the common eel, the electric silurus those of its species inhabiting our rivers and lakes, and the torpedo all others of the ray family. Ancient zoology associated the electric fish with others of its kind which possessed no electric capacity whatever.

In each of these fish the electric organ is constructed in a unique and highly interesting manner. The most simple of all is that of the torpedo. This creature possesses two electric organs, symmetrically placed, one on each side. Like all fish of the ray species it is distinguished by a flat, broad body. However, while the ray usually has a somewhat pointed head, the torpedo has a remarkably wide one. This arises from the fact that in addition to the gills on each side of the head, the falciform electric organs discovered by Redi are also situated there. They extend along the body, one directly under the skin of the back, the other beneath the skin of the stomach. The dimensions of these organs is especially worthy of attention. In a torpedo of ordinary size (35 centimetres in length) the electric organ is about 11 centimetres long, the greatest width 5 centimetres, and the height, (the skin being removed from the back and stomach), 2 centimetres. When prepared, the organ is of the consistency and not unlike a gray, semi-transparent gelatinous substance.

In the electric silurus, as in the torpedo, a symmetrically placed organ is found on each side. It lies on the skin which assumes the thickness of a tough rind. With the exception of the extremities, (the tip of the head and tail), the substance of these organs is embedded in the entire skin of the fish. In the middle line of the back and stomach the two organs come in direct contact, so that we may say the body of the silurus is placed in a tube composed of the two electric organs which unite like two gutter tiles. From the ends of this tube the head and tail of the fish alone project, as the skin covering them contains no electric substance. When in a fresh condition the material composing the organs presents very much the same appearance as that of the torpedo. The size is considerable, the weight being more than one-fourth that of the entire body.

The electric organs of the gymnotus are by far the most extensive. This creature, the largest specimen of whose species measures the length of a man and the thickness of a good-sized thigh, does not possess the same strongly-developed, muscular constitution which distinguishes our common eel. Almost the whole body from the back of the head to the end of the tail is composed of electric organs which are situated along the vertebral column in two pairs, a large one above and a small one beneath. Above these organs, and aside from the vertebral column, are the muscles (reduced to very insignificant dimensions) which move the powerful body.

This, then, is the way in which the electric organs are distributed among the three fish, without causing them to differ in any other respect from the remainder of their species. Yet we must make one limited addition to this assertion.

The electric organs are all distinguished by an extraordinary abundance of nerves. To each individual organ is attached an immense number of nerve-fibres, which complete it in some remarkable way yet to be spoken of, and which must be regarded as a constituent part of the organ itself.

It is, of course, understood that these nerve-fibres (called electric nerves) are entirely wanting in the organization of the non-electric fish, and nothing analagous with them can be found in the latter's entire construction.

But we must go a step further. It is a fixed law, governing the entire vertebrate world, that every nerve shall spring from a particular point, or rather from a certain group of cells belonging to the organs of the nerve centres (brain and spinal cord). This group is called the centre of origin of these nerves. In many cases the individual nerve-fibres have been successfully traced to the separate ganglion groups (nerve cell groups) of a like number of cells. In these cells single apophyses have been well authenticated and make it evident that the latter become nerve-fibres in course of time; or rather the nerve fibres have been carefully observed as to their position in regard to the centre of origin, and thus warrant the conclusion that they unite with the apophyses of the ganglion cells.

In the torpedo the powerful electric nerves (five on each side) unite with the centre organ between the brain and spinal column, and form their centre of origin on each side in a massive lobe first described by Alexander von Humboldt, and called the lemon lobe on account of its peculiar color. Now the name has been changed to electric lobe.

A close microscopic examination has shown that this consists entirely of ganglion cells and nerve fibres. These excited special interest for some time among anatomists, as it was discovered that their dimensions much surpassed those of all other nerve fibres and ganglion cells.

Then Bilhary disclosed the fact that in the electric silurus, the numberless nerves which support the electric organ originate from the subdivision of a single collossal nerve; also that this enormous fibre springs from an equally large ganglion cell visible to the naked eye, which lies imbedded in a substance of its own not far from the upper end of the spinal column, and forms the electric centre of origin of the fish.

The nerves which constitute the electric organ of the gymnotus are unusually great in number (200—230 on each side). They are situated along the entire length of the spinal column and at each interval between two dorsal vertebra a nerve projects. Their origin has not yet been explained in a satisfactory manner, but the most probable supposition is that they spring from certain large ganglion cells which are found along the spinal column.

The above details show us that the three electric fish possess specific electric organs and electric nerves, and that the construction and situation of the central organs differs exceedingly from that of the nerves. If a closer examination is made, it will be seen that the three electric organs harmonize perfectly with the essential parts of their structure, and that an anatomical principle binds them together.

This anatomical principle is nothing more than the construction of the electric organs out of many thousands of perfect, symmetrically arranged layers, the so-called electric strata in which the nerves terminate. Apart from these layers there is no other demonstrable formula of the electric organs except blood vessels and tissues.

In the electric organ of the torpedo which lies between the paralleled flat portions of the back and stomach, the electric layers are arranged in a corresponding manner. They are distinguished by having a rough and a smooth side. The latter is turned towards the back, the former towards the stomach. The rough side is so called from the countless nerve ramifications which spread themselves on all sides, and at last become so diminutive that they appear to melt into the electric layers composed of a pithy, albumen-like substance. It is very much to the point that these thousands of layers should be identified as a summary of electro-motory units, and that the construction of each individual layer should be investigated in order to discover, if possible, the reason for the phen-

omenon. The fact that the nerves of the layers turn towards the negative flat portions of the fish when the shock takes place, appeared to give a by no means unimportant hint, and to indicate a relation existing between the disposition of the nerves and that of the shock.

With the gymnotus all the different proportions harmonize completely with each other. The electric layers are situated vertically along the body. A rough and a smooth side are quite distinct. In the latter numberless nerves are embedded. The rough side corresponds to the tail and the smooth side to the head. The same relations exist here as in the torpedo. With the gymnotus, however, the current goes from head to tail, and when the electric shock takes place, the nerves of the strata turn towards the negative pole of the fish.

This harmony between the nerves and the electric shock leads us to suppose that an effectual and universally recognized law is in question. Yet, while the whole world was expecting a like agreement in regard to the malopternus, anatomical and physical investigations of its organs showed a considerable difference existing between them and the two first described. It is true that electric layers are there, and also situated vertically along the creature's body. The nerves too, unite in the same manner and on the same side with the layers. But a rough and a smooth side cannot be distinguished here as in the torpedo and gymnotus, for the layers are not furnished with so great a number of nerve fibres. On the contrary, one single nerve fibre is implanted in the centre and corresponds with the tail of the fish, as is the case of the gymnotus. When the shock takes place, however, this is the positive and *not* the negative pole.

So far, no one has succeeded in removing this contradiction, and it is more than questionable whether the resemblance agreed upon by Pacini between the anatomical and physical relations of the electric layers, has really the value of a natural law or not. In laying down this principle an important anatomical fact is first to be considered which later years have succeeded in ascertaining. It has been said that the electric layers in the gymnotus possess an identical microscopical structure, which formerly was only known in the torpedo and silurus. Unfortunately, the gymnotus has not been successfully examined in regard to this, therefore the question concerning the physical explanation of the electric shock has not much significance.

These are the facts which Anatomy is capable of producing in regard to the structure of the electric organs, especially in all that concerns their relations with the nervous system. No less great is the number of facts ascertained by the means of experimental physiology, which first facilitated a thorough understanding of the electric organs and their import.

Before these facts are individualized, however, it is necessary to make a few general remarks concerning the physiology of the nervous system.

All the organs contained in the body with which those springing from the centre of origin of the nervous system unite, can be divided into two classes, according to the relation they bear to the nervous system.

First class: Organs with centripetal nerves (commonly called organs of sense). These are characterized by the fact that any influence directed upon them through the nerves is conducted to the organs of the nervous system, and there produces a sensation. This perception arises from the peculiar nature of the nerve in question. If the retina of the eye is attracted by anything, a sensation of light is produced, which influences the nerves of the skin. Any excitation of the organs of hearing causes a resounding sensation upon the nerves. Indeed, it is not even necessary that the corresponding organ should be directly attached at all. The same effect is produced when the nerve of the organ is cut and any excitation made upon the end which does not unite with the central organ. If the influence is directed upon the periphery end of the divided nerve which is attached to the organ of sense, no natural effect will be perceived.

Second class: Terminal organs with centrifugal nerves. These do not include the organs of sense, according to any general signification. The muscles, the organs of sight, and probably the glands, all belong here. These organs, differing so completely one from the other, bear the same general relations towards the nervous system. Every influence which effects the centre of origin, particularly one made at will by the animal in question, is conducted through the nerves of the final organ, and, according to the nature of the latter, produces muscular contraction. Here also it is unnecessary that the excitation should proceed directly from the centre of origin. The same effects appear when the nerve of the terminal organ is cut and any influence directed upon it. If the excitation be directed upon the end of the nerve in connection with the centre of origin, there is no result.

It is to the second class that the electric organs belong. They are under the direct influence of the nervous system just as other organs are. They are distinguished merely by their peculiar properties, and they develop under the controlling power of the nervous system just as the muscles contract and expand by the same means.

The proof of this analogy has been given in a most complete manner by Physiology, and we will repeat it here, or, rather, give the principal details.

If the centre of origin of a muscle or any group of muscles is excited in an animal, contraction takes place. A needle thrust into the electric strata of a living torpedo occasions an immediate electric discharge.

The same results are observed when the excitation is made upon the end of the nerve connected with a muscle instead of the centre of origin.

If an electric excitation is selected for this experiment it will be seen that every irritation, however superficial, made upon the nerve proceeding from the muscle is followed by an electric shock.

If the irritations follow each other in quick succession the convulsions will be reduced to an apparently invariable state of contraction which Physiology designates as tetanus. The same excitations directed upon the electric organ produce the same effects. This is called electric tetanus.

It has been observed that a short space of time ($\frac{1}{100}''$) elapses between the nerve excitation and the beginning of the convulsion during which the muscle remains perfectly motionless. When the nerve of the electric organ is irritated the same result occurs.

The muscles and electric organs of animals which have been poisoned by strychnine produce very interesting effects. The nature of this poison consists (as physiology expresses it), in a condition of complete reflex irritability, that is, a state in which every excitation experienced by the nerves of sense is answered by some modification of the centrifugal nerves. If, for instance, we take a rabbit or frog which is poisoned by strychnine and shake it violently or scream loudly, you will see that spasmodic muscular contraction follows each successive irritation. If an electric fish is poisoned by strychnine the same contractions are produced, followed by an electric discharge.

We must not forget to mention that the electric organs as well as the muscles are liable to fatigue, and that just as the latter lose their capacity for contraction after continuous labor, so are the former incapable of producing any effect after repeated discharges have taken place.

The immense number of concordant facts which can be proved in regard to the electric organs and muscles, has induced physiologists to assume that an especial anatomical and physiological relation exists between them, and many consider the electric organs to be muscles remodelled in some peculiar way in which the development of electricity instead of force, and the electric shock instead of contraction, had taken place by some inexplicable means. Such suppositions as these stand in direct

opposition to physiological, chemical and anatomical facts, which recognize a vast difference between these two organs.

The preference certainly is due to that mode of investigation which casts away all artificial proofs of closer relationship between the muscles and the electric organs and regards them as indepeudent and well-authorized members. Indeed, the reasons given by those who accept an especial connection between the two are formed merely upon the identity of this relationship with the nervous system, and not upon any similarity to the actual qualities peculiar to these organs. Such grounds, however, can have no importance as regards this question and can bring the electric organs no nearer to the muscles than to the organs of sight or any other organ.

But are the electric organs really so independent and isolated in the animal organization? And to what freak of nature are we indebted for the remarkable fact that out of all the fish that exist, only three are distinguished by such powerful weapons? The theory of evolution which now rules organic natural sciences, always has a well-tried domestic remedy on hand for such questions. This theory discovers in formations like the electric organs which stand out as prominent exceptions to the conformity of animal construction, the distinct remains of a powerfully developed species belonging to an early epoch of geology, or, in other words, the solitary descendants of a once mighty family. According to this, the appearance of the electric organs in the three fish may seem much less mysterious, and the great anatomical diversities which exhibit themselves throughout these organs are, perhaps, best explained by the idea that in these fish we have before us the final issue of a powerful species, the last remains of an extinct family. That such a family did exist is proved by the discovery of a petrified torpedo in the tertiary strata of Monte Bolca in Verona.

But also in the cotemporary creation the electric organs are not so badly devoloped as a superficial observer might suppose. In the non-electric torpedo of the *Kaja* species, and also those which are found in the African rivers, peculiarly constructed organs have been discovered from which an electric effect cannot be produced, but which, nevertheless, are composed of strata similar to the real electric organs. These may, perhaps, be correctly termed electric organs, which are either newly constructed or else in a state of incomplete development.

The materials so far collected by anatomists and physiologists concerning this question do not admit of a marked decision. The organs present many things in common with the electric strata it is true, but beyond this further investigation seems useless.

In one other respect physiology is likewise unable to give a definite explanation. E. du Bois-Reymond was the first to ask how it happened that the electric fish was not the victim of its own power, and how it was possible that the forcible electric discharges which killed other fish completely escaped the electric fish itself.

Now we all know that the nerves and muscles of the electric fish are excited by means of an electric current, and a much stronger one is perhaps required here than would be the case with other animals, yet the electric discharges, although of such force, produce no effect whatever upon the fish. There are influences at work here, which so far we are unable to understand. We naturally suppose, however, that the great dimensions of the nerve fibres and ganglion cells, together with a vigorous nervous system, have a great deal to do with it.

In conclusion, it still remains for us to put the greatest question of all concerning the electric fish, namely: what is the origin of that powerful force which at the creature's will so suddenly appears and departs with equal rapidity, and also what is the precise mechanism of the electric organs?

It has been shown that as science advanced, the electric fish became better known and more carefully studied. The ancients were only aware that such a thing existed; a conviction, however, that they were incapable of analysing further. Redi taught us to consider the electric organs as the apparatus which produced the effect. E. du Bois-Reymond put the electric strata in place of the electric organs, by proving that the mechanism of the latter was reduced to the combined action of countless analogous electro-motory monads, which was explained by the supposition that when the electric discharge occurred one part of the strata was positive and the other negative. By this means our question concerning the mechanism of the electric organs is partially answered. It now remains to ask what takes place when the electric discharge occurs?

Now, in order to imitate the effects produced by the malopternus, it requires the strongest electro-motor apparatus that can be found. The natural philosopher must use the most powerful batteries contained in his labratory, if he wishes to *approach* the force which causes 2½ pounds of water, salt and albumen to come under its influence.

The muscles are no less powerful. The dorsal muscle of a frog consists of a few grammes of water, salt and albumen, and yet it is capable of lifting a kilometre. In both cases an extraordinary development is apparent, mechanical in one and electric in the other.

Hitherto, no one has succeeded in correctly establishing the facts relating to this mechanism. Nevertheless, concerning the electric eel there is an accepted theory, which explains all the phenomena in a most satisfactory manner.

This theory originated with Colladon and E. du Bois-Reymond, and states that in the electric substance, dispolary electro-moter molecules are to be found.

In a state of repose they turn towards their pole in every direction, or else in two ways opposed to each other, so that the electricity arises on all sides and disappears without. When the shock takes place, the possitive pole is turned quickly towards the electric organ whence the positive current proceeds.

OBSERVATIONS ON ICE AND ICEBERGS IN THE POLAR REGIONS.*

By Lieutenant F. SCHWATKA, U. S. N.

The formation of icebergs, from the terminal fronts of glaciers, has long been a disputed point among *savants*, some contending that they derive their origin from the corroding action of the water, undermining their projecting faces until the weight of the superincumbent mass, acting as a lever, overcame the cohesive power of the glacier along some line of least resistance, when the berg fell into the sea, and was wafted away by the tide-winds and currents. Others can only account for such huge mountains of ice by supposing that the glacier, slowly crawling into the sea, and plunging beneath a denser fluid, has a bouyant effort or tendency to rise, which, at last, becomes so great that it overcomes the line of least resistance, near the shore, and the berg rises into the sea, to be at the further mercy of its uncertain elements. Both theories have proved to be correct. The former generally occurs where currents, heated in more temperate climes, pour their tepid waters northward, and expend their thermal forces in contending with the vast packs, floes, and glaciers of ice, that obstruct their polar march, and whose fast corroding action has the slow glacier only a comparatively short time in its embraces before it has undermined it. The latter results where the chilled waters from the Pole have but little effect upon the glacial front; and slow as it is, it has time to crawl into the sea to give forth its mighty masses. Sometimes both

* Read before the National Academy of Sciences, New York, 1880.

opposition to physiological, chemical and anatomical facts, which recognize a vast difference between these two organs.

The preference certainly is due to that mode of investigation which casts away all artificial proofs of closer relationship between the muscles and the electric organs and regards them as indepeodent and well-authorized members. Indeed, the reasons given by those who accept an especial connection between the two are formed merely upon the identity of this relationship with the nervous system, and not upon any similarity to the actual qualities peculiar to these organs. Such grounds, however, can have no importance as regards this question and can bring the electric organs no nearer to the muscles than to the organs of sight or any other organ.

But are the electric organs really so independent and isolated in the animal organization? And to what freak of nature are we indebted for the remarkable fact that out of all the fish that exist, only three are distinguished by such powerful weapons? The theory of evolution which now rules organic natural sciences, always has a well-tried domestic remedy on hand for such questions. This theory discovers in formations like the electric organs which stand out as prominent exceptions to the conformity of animal construction, the distinct remains of a powerfully developed species belonging to an early epoch of geology, or, in other words, the solitary descendants of a once mighty family. According to this, the appearance of the electric organs in the three fish may seem much less mysterious, and the great anatomical diversities which exhibit themselves throughout these organs are, perhaps, best explained by the idea that in these fish we have before us the final issue of a powerful species, the last remains of an extinct family. That such a family did exist is proved by the discovery of a petrified torpedo in the tertiary strata of Monte Bolca in Verona.

But also in the cotemporary creation the electric organs are not so badly devoloped as a superficial observer might suppose. In the non-electric torpedo of the *Kaja* species, and also those which are found in the African rivers, peculiarly constructed organs have been discovered from which an electric effect cannot be produced, but which, nevertheless, are composed of strata similar to the real electric organs. These may, perhaps, be correctly termed electric organs, which are either newly constructed or else in a state of incomplete development.

The materials so far collected by anatomists and physiologists concerning this question do not admit of a marked decision. The organs present many things in common with the electric strata it is true, but beyond this further investigation seems useless.

In one other respect physiology is likewise unable to give a definite explanation. E. du Bois-Reymond was the first to ask how it happened that the electric fish was not the victim of its own power, and how it was possible that the forcible electric discharges which killed other fish completely escaped the electric fish itself.

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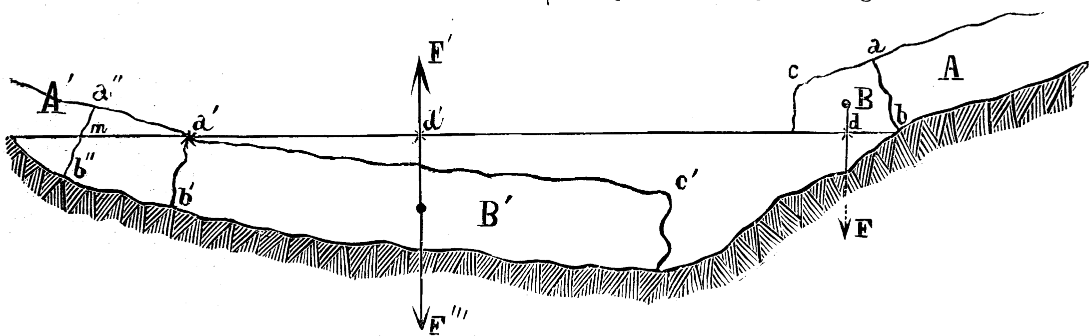
kinds of forces are acting simultaneously upon the same glacier, and while huge icy mountains are at intervals of centuries rising from their dense, watery bed, other and smaller ones are more frequently dropping from its seaward face, for those formed by dropping are far smaller than those which rise into the sea, as the following diagram will serve to show. Although about seven-eighths of an iceberg is submerged, it must not be inferred that, when its height has been determined, seven times that height is its depth below the sea level. If of a tabular shape, this proportion becomes more nearly correct; but if of a pyramidal or conoidal cross section, which is far oftener the case, the lineal proportions of height to depth approach each other more closely, while the volumes, necessary to hydrostatic equilibrium, remain invariable. Their great height, as compared with their breadth shows that these lineal proportions do not obtain beneath the sea level, or the mass, if homogeneous could not be in a state of stable equilibrium, and would topple over, which sometimes happens when the conditions of equilibrium are disturbed by the unsymetrical decrease of its different faces.

The height of bergs, estimated or measured by various Arctic voyagers, varies greatly. During the warm months of summer, when they are most frequently encountered by navigators, they are often surrounded by a hazy mist, due to the condensation of the surrounding moisture by their chilly faces, and the effect is to make them appear much higher than they really are, and to render estimates of their height particularly unreliable.

As about seven-eighths of an iceberg is under water, the curious spectacle, which has often been seen in Polar latitudes, of these monsters ploughing their way against a rapid current, loaded with heavy pack-ice, and in the very teeth of a strong gale of wind, can be readily understood on the theory that the surface current is shallow, and the drifting colossus is only obeying the mandates of a deeper and more powerful agent.



ON HEAT CONDUCTION IN HIGHLY RAREFIED AIR.*

By WILLIAM CROOKES, F.R.S.

The transfer of heat across air of different densities has been examined by various experimentalists, the general result being that heat conduction is almost independent of pressure. Winkelmann (*Pogg. Ann.*, 1875, 76) measured the velocity of cooling of a thermometer in a vessel filled with the gas to be examined. The difficulty of these experiments lies in the circumstance that the cooling is caused not only by the conduction of the gas which surrounds the cooling body, but that also the currents of the gas and, above all, radiation play an important part. Winkelmann eliminated the action of currents by altering the pressure of the gas between 760 and 1 millim. (with decreasing pressure the action of gas currents becomes less); and he obtained data for eliminating the action of radiation by varying the dimensions of the outer vessel. He found that, whereas a lowering of the pressure from 760 to 91.4 millims. there was a change of only 1.4 per cent. in the value for the velocity of cooling, on further diminution of the pressure to 4.7 millims. there was a further decrease of 11 per cent., and this decrease continued when the pressure was further lowered to 1.92 millim.

About the same time Kundt and Warburg (*Pogg. Ann.*, 1874, 5) carried out similar experiments, increasing the exhaustion to much higher points, but without giving measurements of the pressure below 1 millim. They enclosed a thermometer in a glass bulb connected with a mercury pump, and heated it to a higher temperature than the highest point at which observations were to be taken; then left it to itself, and noted the time it took to fall through a certain number of degrees. They found that between 10 millims. and 1 millim. the time of cooling from 60° to 20° was independent of the pressure: on the contrary, at 150 millims. pressure the rate was one and a half times as great as at 750 millims. Many precautions were taken to secure accuracy, but no measure ments of higher exhaustions being given the results lack quantitative value.

It appears, therefore, that a thermometer cools slower in a so-called vacuum than in air of atmospheric pressure. In dense air convection currents have a considerable share in the action, but the law of cooling in vacua so high that we may neglect convection has not to my knowledge been determined. Some years ago Professor Stokes suggested to me to examine this point, but finding that Kundt and Warburg were working in the same direction it was not thought worth going over the same ground, and the experiments were only tried up to a certain point, and then set aside. The data which these experiments would have given are now required for the discussion of some results on the viscosity of gases, which I hope to lay before the Society in the course of a few weeks; I have therefore completed them so as to embody the results in the form of a short paper.

An accurate thermometer with pretty open scale was enclosed in a 1½ inch glass globe, the bulb of the thermometer being in the centre, and the stem being enclosed in the tube leading from the glass globe to the pump.

Experiments were tried in two ways:—

I. The glass globe (at the various exhaustions) was immersed in nearly boiling water, and when the temperature was stationary it was taken out, wiped dry, and allowed to cool in the air, the number of seconds occupied for each sink of 5° being noted.

II. The globe was first brought to a uniform temperature in a vessel of water at 25°, and was then suddenly plunged into a large vessel of water at 65°. The bulk of hot water was such that the temperature remained sensibly the same during the continuance of each experiment. The number of seconds required for the thermometer to rise from 25° to 50° was registered as in the first case.

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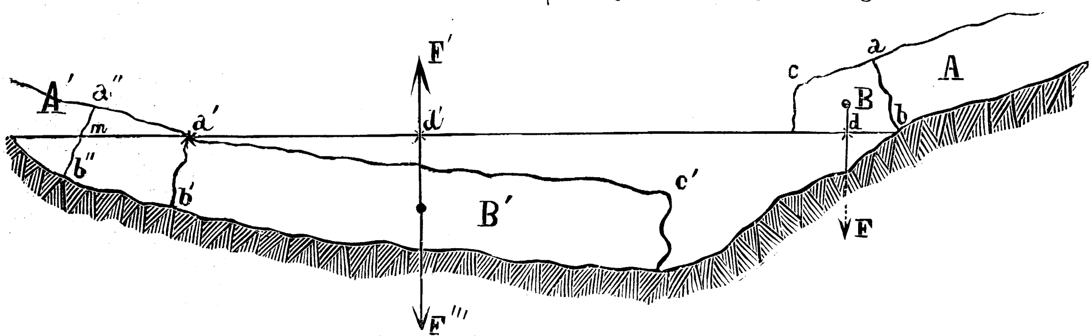

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It was found that the second form of experiment gave the most uniform results; the method by cooling being less accurate, owing to currents of air in the room, etc. The results are embodied in the following Table:—

(Rate of Heating from 25° to 50°.)

TABLE I.

Pressure.	Temperature.	Seconds occupied in rising each 5°.	Total number of seconds occupied.
760 millims.	25°	0	0
	25 to 30	15	15
	30 to 35	18	33
	35 to 40	22	55
	40 to 45	27	82
	45 to 50	39	121
1 millim.	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	25	68
	40 to 45	34	102
	45 to 50	48	150
620 M.*	25°	0	0
	25 to 30	20	20
	30 to 35	23	43
	35 to 40	29	72
	40 to 45	37	109
	45 to 50	53	162
117 M.	25°	0	0
	25 to 30	23	23
	30 to 35	23	46
	35 to 40	32	78
	40 to 45	44	122
	45 to 50	61	183
59 M.	25°	0	0
	25 to 30	25	25
	30 to 35	30	55
	35 to 40	36	91
	40 to 45	45	136
	45 to 50	67	203
23 M.	25°	0	0
	25 to 30	28	28
	30 to 35	33	61
	35 to 40	41	102
	40 to 45	55	157
	45 to 50	70	227
12 M.	25°	0	0
	25 to 30	30	30
	30 to 35	37	67
	35 to 40	41	108
	40 to 45	58	166
	45 to 50	86	252
5 M.	25°	0	0
	25 to 30	38	38
	30 to 35	43	81
	35 to 40	54	135
	40 to 45	71	206
	45 to 50	116	322
2 M	25°	0	0
	25 to 30	41	41
	30 to 35	51	92
	35 to 40	65	157
	40 to 45	90	247
	45 to 50	165	412

There are two ways in which heat can get from the glass globe to the thermometer—(1) By radiation across the intervening space; (2) by communicating an increase of motion to the molecules of the gas, which carry it to the thermometer. It is quite conceivable that a considerable part, especially in the case of heat of low refrangibility, may be transferred by "carriage," as I will call it to distinguish it from convection, which is different, and yet that we should not perceive much diminution of transference, and consequently much diminution of rate of rise with increased exhaustion, so long as we work with ordinary exhaustions up to 1 millim. or so. For if, on the one hand, there are fewer molecules impinging on the warm body (which is adverse to the carriage of heat), yet on the other the mean length of path between collisions is increased, so that the augmented motion is carried further. The number of steps by which the temperature passes from the warmer to the cooler body is diminished, and accordingly the value of each step is increased. Hence the increase in the difference of velocity before and after impact may make up for the diminution in the number of molecules impinging. It is therefore conceivable that it may not be till such high exhaustions are reached that the mean length of path between collisions becomes comparable with the diameter of the case, that further exhaustion produces a notable fall in the rate at which heat is conveyed from the case to the thermometer.

*M=millionth of an atmosphere.

The above experiments show that there *is* a notable fall, a reduction of pressure from 5 M. to 2 M. producing twice as much fall in the rate as is obtained by the whole exhaustion from 760 millims. to 1 millim. We may legitimately infer that each additional diminution of a millionth would produce a still greater retardation of cooling, so that in such vacua as exist in planetary space the loss of heat—which in that case would only take place by radiation—would be exceedingly slow.

PROFESSOR HUXLEY ON EVOLUTION.

At a recent meeting of the Zoological Society, among the papers read was one by Professor Huxley on the application of the laws of evolution to the arrangement of the vertebrata, and more particularly mammalia. The illustrations adduced were those of the history of the horse, principally, so far as is known, from the work of Professor Marsh on the Eocenes of North America. The announcement of the paper had drawn together an unusually large attendance, as it was expected that the marshalling of the facts in Professor Huxley's hands would have great interest in practically substantiating the theory of evolution, which, though foreshadowed by others, took practical shape in the work of Darwin twenty-one years ago.

Professor Huxley began by saying:—There is evidence, the value of which has not been disputed, and which, in my judgment, amounts to proof, that between the commencement of the tertiary epoch and the present time the group of the equidæ has been represented by a series of forms, of which the oldest is that which departs least from the general type of structure of the higher mammalia, while the latest is that which most widely differs from that type. In fact, the earliest known equine animal possesses four complete sub-equal digits on the fore foot, three on the hind foot; the ulna is complete and distinct from the radius; the fibula is complete and distinct from the tibia; there are 44 teeth, the full number of canines being present, and the cheek-teeth having short crowns with simple patterns and early-formed roots. The latest, on the other hand, has only one complete digit on each foot, the rest being represented by rudiments; the ulna is reduced and partially anchylosed with the radius; the fibula is still more reduced and partially anchylosed with the tibia; the canine teeth are partially or completely suppressed in the females; the first cheek-teeth usually remain undeveloped, and when they appear are very small; the other cheek-teeth have long crowns, with highly complicated patterns and late-formed roots. The equidæ of the intermediate ages exhibit intermediate characters. With respect to the interpretation of these facts two hypotheses

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PROFESSOR HUXLEY ON EVOLUTION.

At a recent meeting of the Zoological Society, among the papers read was one by Professor Huxley on the application of the laws of evolution to the arrangement of the vertebrata, and more particularly mammalia. The illustrations adduced were those of the history of the horse, principally, so far as is known, from the work of Professor Marsh on the Eocenes of North America. The announcement of the paper had drawn together an unusually large attendance, as it was expected that the marshalling of the facts in Professor Huxley's hands would have great interest in practically substantiating the theory of evolution, which, though foreshadowed by others, took practical shape in the work of Darwin twenty-one years ago.

Professor Huxley began by saying:—There is evidence, the value of which has not been disputed, and which, in my judgment, amounts to proof, that between the commencement of the tertiary epoch and the present time the group of the equidæ has been represented by a series of forms, of which the oldest is that which departs least from the general type of structure of the higher mammalia, while the latest is that which most widely differs from that type. In fact, the earliest known equine animal possesses four complete sub-equal digits on the fore foot, three on the hind foot; the ulna is complete and distinct from the radius; the fibula is complete and distinct from the tibia; there are 44 teeth, the full number of canines being present, and the cheek-teeth having short crowns with simple patterns and early-formed roots. The latest, on the other hand, has only one complete digit on each foot, the rest being represented by rudiments; the ulna is reduced and partially anchylosed with the radius; the fibula is still more reduced and partially anchylosed with the tibia; the canine teeth are partially or completely suppressed in the females; the first cheek-teeth usually remain undeveloped, and when they appear are very small; the other cheek-teeth have long crowns, with highly complicated patterns and late-formed roots. The equidæ of the intermediate ages exhibit intermediate characters. With respect to the interpretation of these facts two hypotheses

and only two, appear to be imaginable. The one assumes that these successive forms of equine animals have come into existence independently of one another. The other assumes that they are the result of the gradual modification undergone by the successive members of a continuous line of ancestry. As I am not aware that any zoologist maintains the first hypothesis, I do not feel called upon to discuss it. The adoption of the second, however, is equivalent to the acceptance of the doctrine of evolution so far as horses are concerned, and in the absence of evidence to the contrary, I shall suppose that it is accepted. Since the commencement of the eocene epoch, the animals which constitute the family of the equidæ have undergone processes of modification of three kinds:—1, there has been an excess of development of one part of the oldest form over another; 2, certain parts have undergone complete or partial suppression; 3, parts originally distinct have coalesced. Employing the term "law" simply in the sense of a general statement of facts ascertained by observation, I shall speak of these three processes by which the eohippus form has passed into equus as the expression of a three-fold law of evolution. It is of profound interest to remark that this law or generalized statement of the nature of the ancestral evolution of the horse, is precisely the same as that which formulates the process of individual development in animals generally, from the period at which the broad characters of the group to which an animal belongs are discernible onwards. After a mammalian embryo, for example, has taken on its general mammalian characters, its further progress towards its special form is affected by the excessive growth of one part or relation to another, by the arrest or suppression of parts already formed, and by the coalescence of parts primarily distinct. This coincidence of the laws of ancestral and individual development creates a strong confidence in the general validity of the former, and a belief that we may safely employ it in reasoning deductively from the known to the unknown. The astronomer who has determined three places of a new planet calculates its place at any epoch, however remote; and, if the law of evolution is to be depended upon, the zoologist who knows a certain length of the course of that evolution in any given case may with equal justice reason backwards to the earlier but unknown stages. Applying this method to the case of the horse, I do not see that there is any reason to doubt that the eocene equidæ were preceded by mesozoic forms, which differed from eohippus in the same way as eohippus differs from equus. And thus we are ultimately led to conceive of a first form of the equine series, which, if the law is of general validity, must need have been provided with five sub-equal digits on each plantigrade foot, with complete sub-equal antebrachial and crural bones, with clavicles, and with, as at present, 44 teeth, the cheek-teeth having short crowns and simple ridged or tuberculated patterns. Moreover, since Marsh's investigations have shown that the older forms of any given mammalian group have less developed cerebral hemispheres than the later, there is a *primâ facie* probability that this primordial hippoid had a low form of brain. Further, since the existing horse has a diffuse allantoic placentation, the primary form could not have presented a higher, and may have possessed a lower condition of the various modes by which the fœtus derives nourishment from the parent. Such an animal as this, however, would find no place in any of our systems of classification of the mammalia. It would come nearest to the lemuroidea and the insectivora, though the non-prehensile pes would separate it from the former, and the placentation from the latter group. A natural classification is one which associates together all those forms which are closely allied and separates them from the rest. But, whether in the ordinary sense of the word "alliance," or in its purely morphological sense, it is impossible to imagine a group of animals more closely allied than our primordial hippoids are with their descendants Yet, according to existing arrangements, the ancestors would have to be placed in one order of the class of mammalia, and their descendants in another. It may be suggested that it might be as well to wait until the primordial hippoid is discovered before discussing the difficulties which will be created by its appearance. But the truth is that that problem is already pressing in another shape. Numerous "lemurs," with marked ungulate characters are being discovered in the older tertiaries of the United States and elsewhere; and no one can study the more ancient mammals with which we are already acquainted without being constantly struck with the insectivorous characters which they present. In fact, there is nothing in the dentition of either primates, carnivores, or ungulates, which is any means of deciding whether a given fossil skeleton, with skull, teeth, and limbs almost complete, ought to be ranged with the lemurs, the insectivores, the carnivores, or the ungulates. In whatever order of mammals a sufficiently long series of forms has come to light, they illustrate the three-fold law of evolution as clearly, though, perhaps, not so strikingly, as the equine series does. Carnivores, artiodactyles, and perissodactyles all tend, as we trace them back through the tertiary epoch, towards less modified forms which will fit into none of the recognized orders, but come closer to the insectivora than to any other. It would, however, be most inconvenient and misleading to term these primordial forms insectivora, the mammals so-called being themselves more or less specialized modifications of the same common type, and only, in a partial and limited sense, representatives of that type. The root of the matter appears to me to be that the palæontological facts which have come to light in the course of the last ten or fifteen years have completely broken down existing taxonomical conceptions, and that the attempts to construct fresh classification upon the old model are necessarily futile. The Cuvieran method, which all modern classifiers have followed, has been of immense value in leading to the close investigation and the clear statement of the anatomical characters of animals. But its principle, the association into sharp logical categories defined by such characters, was sapped when Von Baer showed that, in estimating the likenesses and unlikeness of the animals, development must be fully taken into account; and if the importance of individual development is admitted, that of ancestral development necessarily follows. If the end of all zoological classification is a clear and concise expression of the morphological resemblances and differences of animals, then all such resemblances must have a taxonomic value. But they fall under three heads:—(1) those of adult individuals: (2) those of successive stages of embryological development or individual evolution; (3) those of successive stages of the evolution of the species, or ancestral evolution. An arrangement is "natural," that is, logically justifiable, exactly in so far as it expresses the relations of likenesses and unlikenesses enumerated under these heads. Hence, in attempting to classify the mammalia, we must take into account not only their adult and embryogenetic characters, but their morphological relations, in so far as the several forms represent different stages of evolution. And thus, just as the persistent antagonism of Cuvier and his school to the essence of Lamarck's teachings (imperfect and objectionable as these often were in their accidents) turns out to have been a reactionary mistake, so Cuvier's no less definite repudiation of Bonnet's "*échelle*" at the present day, the existence of a "scala animantium," is a necessary consequence of the doctrine of evolution, and its establishment constitutes, I believe, the foundation of scientific taxonomy. Many years ago, in my lectures at the Royal College of Surgeon, Is particularly insisted on the central position of the insectivora among the higher mammalia; and further study of this order and of the rodentia has only strengened my conviction that any one

who is acquainted with the range of variation of structure in these groups possesses the key to every peculiarity which is met with in the primates, the carnivora, and the ungulata. Given the common plan of the insectivora and of the rodentia, and granting that the modifications of the structure of the limbs, of the brain, and of the alimentary and reproductive viscera which occur among them may exist and accumulate elsewhere, and the derivation of all eutheria from animals which, except for their diffuse placentation, would be insectivores, is a simple deduction from the law of evolution. I venture to express a confident expectation that investigation into the mammalia fauna of the mesozoic epoch will, sooner or later, fill up these blanks.

RECENT DISCOVERIES RELATING TO THE DOUBLE STARS OF THE DORPAT CATALOGUE.

By S. W. Burnham.

The distinguished Russian astronomer, Struve, published in 1837 the results of a thorough examination of the heavens for the discovery of double stars between the north pole and 15° south declination. This great catalogue, *Mensuræ Micrometricæ*, included all the double stars within these limits known prior to the observations of Struve, mainly due to the researches of Sir William Herschel, and at the time of its publication presented all that was known on this subject of astronomy. The whole number of double stars catalogued and measured by Struve was about 3000. The superiority of the telescope used at Dorpat for this class of work, over the much larger reflectors employed by the Herschels, is repeatedly shown by the observations. Many of the Herschel pairs, observed with apertures from eighteen inches to four feet, were found by Struve with the 9.6-inch refractor to be really triple, one of the components being a close pair. When Sturve's great work was published, it seemed as though there was little left for subsequent observers to do except in the way of re-observing the Struve stars. So complete and systematic had been his scrutiny of the northern heavens, it was considered that new discoveries among the stars found by Struve to be single would necessarily be of rare occurrence, and particularly after the publication, in 1850, of the Pulkowa Catalogue of 500 stars, which comprised omitted stars and later discoveries, principally by Otto Struve, the successor of his father as Director of the new Imperial Observatory. This last mentioned catalogue was much more interesting, with respect to the class of stars it contained, than the other. The Pulkowa 15-inch refractor was in every respect superior to the Dorpat glass, as well as larger. Substantially all the wide and comparatively easy pairs had been collected in *Mensuræ Micrometricæ*, so that later discoveries were necessarily either very close pairs, or the components were very unequal, and, therefore, this catalogue furnishes a much larger proportion of binary and other interesting systems. In the twenty-five years following this epoch, the whole number of double star discoveries by all observers would not exceed fifty; but many important series of measures of the Struve stars were made by English, German and Italian astronomers, and this work was steadily continued at Pulkowa, resulting in showing the periods and motions of many of the more rapid binary systems, and the relations of other double stars.

That these catalogues were really very incomplete, with reference to the number of double stars actually existing, is apparent from the fact that the writer in the last ten years has discovered at least 900 new pairs, and more than half of them with a telescope greatly inferior in size to the smallest of the instruments used by the Russian astronomers. That there was left much that was new to discover in the Struve stars will appear from the number which have been again divided by later observers. In some instances, doubtless, the close pair was missed by Struve because it was single or much closer at that time, but certainly in the great majority of instances this is improbable, and the true explanation will probably be found in the improved defining power of the later refracting telescopes. For double star work more than any other, perfect definition is of the first importance. Something may be done in observing the moon, planets, nebulæ, etc., with a large instrument of poor definition, but for the discovery or measurement of close and difficult double stars it is practically useless. It should be mentioned as a fact that every star in the following table was discovered with a refracting telescope.

The following list comprises all the stars of the Dorpat Catalogue where a closer component has been discovered since the observations of Struve. More than half of these

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3..	39	....	19 .90	0 .40	Dembowski
4..	157	....	12 .40	0 .85	Burnham
5..	171	....	29 .69	3 .69	Burnham
6..	205	γ Andromedæ.	10 .33	0 .50	O. Struve
7..	258	....	70 .30	1 .20	Burnham
8..	318	20 Persei.....	14 .04	0 .34	Burnham
9..	366	....	48 .97	1 .99	Burnham
10..	439	....	23 .70	0 .40	Burnham
11..	610	7 Camelopardi	25 .64	1 .24	Dembowski
12..	668	β Orionis.....	9 .14	0 .2?	Burnham
13..	692	Orionis 82....	34 .86	0 .48	Burnham
14..	707	....	27 .77	1 .11	Burnham
15..	721	....	24 .32	0 .46	Burnham
16..	808	....	16 .06	2 .60	Dembowski
17..	888	....	2 .83	0 .27	Burnham
18..	1019	Canis Maj. 136	37 .84	6 .12	Dembowski
19..	1026	Canis Maj. 139	17 .85	0 .48	Burnham
20..	1057	....	15 .87	0 .69	Burnham
21..	1097	....	29 .34	5 .93	Dembowski
22..	1179	....	19 .75	3 .76	Burnham
23..	1481	....	20 .20	0 .80	Burnham
24..	1516	....	7 .90	7 .61	O. Struve
25..	1780	86 Virginis (AC)	26 .94	1 .61	(AB) Burnham
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30..	2287	....	22 .33	1 .71	Burnham
31..	2306	....	12 .81	0 .95	Dembowski
32..	2342	....	28 .80	8 .86	Burnham
33..	2435	(AC)	10 .73	1 .43	(AB) Burnham
				2 .90	(CD) Howe
34..	2479	Cygni 4	6 .72	0 .57	Dembowski
35..	2481	....	4 .03	0 .40	Secchi
36..	2535	....	26 .31	1 .22	Dembowski
37..	2538	....	52 .81	4 .37	Burnham
38..	2539	....	5 .60	4 .78	Burnham
39..	2549	....	22 .86	1 .93	Burnham
40..	2570	....	4 .16	0 .29	A. G. Clark
41..	2589	ζ Sagittæ.....	8 .77	0 .25	A. G. Clark
42..	2607	Cygni 116....	3 .23	0 .3	O. Struve
43..	2630	(AD)	11 .30	6 .47	(AB) Burnham
				7 .75	(AC) Burnham
44..	2657	....	11 .71	0 .60	O. Struve
45..	2690	....	14 .88	0 .56	Dawes
46..	2704	β Delphini....	35 .06	0 .20	Burnham
47..	2777	δ Equulei....	37 .98	0 .35	O. Struve
48..	2793	....	26 .51	0 .56	Burnham
49..	2815	....	7 .50	0 .90	Dembowski
50..	2824	κ Pegasi......	11 .76	0 .27	Burnham
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stars have been discovered within the last eight years, and it is very probable that many new additions will be made as the large refractors now in use engage in this work. This list would be much extended by including stars to which more distant companions have been detected, but most, if not all of them, are too distant to make any physical relation probable, and are of very little interest. The first column gives a number for reference; the second column, Struve's number; the third, the name of the principal star, when found in Flamsteed or Bode; the fourth, the distance of the stars recorded by Struve; the fifth, the distance of the new star; and sixth, the name of the discoverer.

Many of the close pairs are known to be binaries, and in some cases it is probable the three stars form one system. When any change has occurred, the most recent measures of distance are given.

ASTRONOMY.

SWIFT'S COMET.

A new determination of the orbit of Swift's periodic comet has just been made by Mr. Winslow Upton of the U. S. Naval Observatory, based upon observations made at Washington, October 25, November 23, and December 22, 1880. No assumption was made with regard to the period of resolution or the eccentricity. The following are the elements obtained, and communicated to the *Astronomische Nachrichten:*

Epoch, 1880, Oct. 25. 5 Washington mean time.

M	357°	48′	49.3″	
☊	296	41	55.4	1880.0
ω	106	18	13.8	1880.0
i	5	31	3.5	1880.0
ϕ	42	31	39.7	
$\log a$	0.518438			
μ	592.0373″			

The period obtained from these elements is 2189 days, which confirms the fact already announced by Mr. Chandler and others that the comet has made two revolutions since its appearance in 1869. The period obtained is also nearly identical with that given by Prof. Frisby in "SCIENCE," which he derived from observations separated by intervals of only 13 days. The comet could not have been seen at its return in 1875, as the sun was between it and the earth, and it is probable that its next return in 1886 will be unobserved for the same reason, though a careful computation which shall take into account the perturbations of the comet due to the action of the planets will be necessary to determine the question.

Professor E. S. Holden, of the Naval Observatory at Washington, has accepted the managership of the Washburn Observatory in Madison, Wis., the position made vacant by the recent death of Professor Watson. Professor Holden will enter upon his duties in a few weeks.

ASTRONOMICAL MEMORANDA:— (Approximately computed for Washington, D. C., Monday, January 24, 1881.)

Sidereal time of Mean Noon. 20h. 16m. 37s.
Equation of time.......... 12 29
mean noon *preceding* apparent noon.

The *Sun*, having passed the winter solstice, has reached a declination of 19° 3′ south.

The *Moon* reached its Last Quarter on Jan. 22d 16h., or 4 A. M. of Jan. 23.

New Moon comes on Jan. 29d. 8h., and the First Quarter on Feb. 5d. 8h. On the morning of the 24th the Moon crosses the meridian at about a quarter of seven.

Mercury, still invisible, comes into superior conjunction with the sun on the 26th, passes to his eastern side, and becomes evening star. Mercury is in conjunction with the Moon on the morning of Jan. 30.

Venus is evening star, and throughout the month increases her distance from the sun as she approaches the earth. She follows the sun by nearly three hours and is 3° south of the equator.

Mars is morning star, rising about six o'clock, and slowly traveling away from the sun.

Jupiter, evening star, crosses the meridian about half past four:—R. A. 0h. 53m., Dec. 4° 21′ north.

Saturn also is evening star, having reached quadrature, or halfway from opposition to conjunction, on the 12th, when he was on the meridian at six. Saturn and Jupiter, it will be noticed, are still steadily approaching each other.

Uranus crosses the meridian at about 3 o'clock in the morning, at a declination of 7° 21′ north, and cannot claim any especial attention at present.

Neptune is in R. A. 2h. 39m; Dec. 13° 36′ north. It reaches quadrature on the 30th, and will be found in conjunction with the Moon on—Feb. 4th.

IN the *Popular Science Monthly* for January, 1881, Dr. Leonard Waldo gives an interesting description of the method employed at the Yale Observatory, for comparing with the standards of that institution, thermometers which have been sent there for verification by physicians, instrument makers and others. He calls attention to the fact that thermometers, even if from makers of established reputation, are liable to errors much greater than is commonly supposed, and he points out the necessity of having such errors carefully determined.

WE learn from the *Comptes Rendus* that Janssen has made preparations at Meudon to repeat Dr. Draper's experiments on the photography of the Nebula in Orion, and that for this purpose he proposes to construct upon a large scale a telescope of short focus quite similar to the one with which he obtained a very luminous spectrum of the Corona, in 1871. Janssen has also made some experiments in photographing the chromosphere. The exposure is continued so long that the solar image becomes positive to the very circumference, without going beyond it. The chromosphere is then shown in the form of a dark ring with a thickness of 8″ or 10″. He has compared positive and negative solar photographs taken on the same day and with the same instrument, and the measurement of the diameter shows that the dark ring in question is wholly outside of the solar disk.

DR. WARREN DE LA RUE has been elected a corresponding member of the Paris Academy of Sciences in the section of Astronomy, and M. Sella a corresponding member in the section of Mineralogy.

THE Rumford medal of the Royal Society has been awarded to Dr. William Huggins for his work on celestial spectroscopy, and the Copley medal to Prof. J. J. Sylvester of Johns Hopkins University for researches in pure mathematics. W. C. W.

ECLIPSE OF THE SUN.

To the Editor of "SCIENCE:"

I would like to add a sentence to the fourth paragraph of my letter in last week's "SCIENCE" giving my observations of the recent partial eclipse of the sun. After the words "solar limb" I would add, "on the eastern side of the sun the phenomenon was considerably less prominent and only visible at the time of greatest obscuration, and when the slit was quite close to the sun's limb."

L. TROUVELOT.

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Epoch, 1880, Oct. 25. 5 Washington mean time.

$$\begin{array}{rl} M & 357^\circ\ 48'\ 49.3'' \\ \Omega & \left.\begin{array}{l}296\ \ 41\ \ 55.4 \\ 106\ \ 18\ \ 13.8 \\ \ \ 5\ \ 31\ \ \ 3.5\end{array}\right\}1880.0 \\ \omega & \\ i & \\ \phi & 42\ \ 31\ \ 39.7 \\ \log a & 0.518438 \\ \mu & 592.0373'' \end{array}$$

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ASTRONOMICAL MEMORANDA:— (Approximately computed for Washington, D. C., Monday, January 24, 1881.)

Sidereal time of Mean Noon.	20h.	16m.	37s.
Equation of time..........		12	29

mean noon *preceding* apparent noon.

The *Sun*, having passed the winter solstice, has reached a declination of 19° 3′ south.

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URANIA.

AN INTERNATIONAL JOURNAL OF ASTRONOMY.

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What chiefly induces us to increase the number of scientific periodicals by a new one is the circumstance that every year many astronomical papers and memoirs of great value are published in Transactions or Proceedings of Learned Societies, and, in consequence, remain unknown to many astronomers. In publishing *Urania* it is our aim to provide a receptacle for papers of this kind, which, we trust, will thereby become more generally known, and by preparing reviews or abstracts of all papers of any importance published in places where they seem likely to be overlooked, we shall endeavor to keep our readers as fully acquainted as possible with the progress of astronomical research. At the same time observations or ephemerides of planets, comets, etc., will not be excluded, and in addition to purely astronomical subjects, the essentially cosmical phenomena of magnetism as connected with Aurorae will also meet with their share of attention.

The journal will be printed in Dublin, and will be issued in numbers of from 16 to 24 pages each, demy 4to, whenever we have material enough for a number. Longer memoirs will not be cut up in several parts, but will be printed together in one number, or carried through two numbers without interruption. Shorter numbers will be issued whenever subjects of more immediate interest shall require it, and in particular ephemerides of comets, etc., will be issued on advance sheets, if necessary. Twelve numbers will contain 240 pages, and will form a volume.

The numbers will be sent by post to all subscribers. The subscription for one volume, including postage to all countries in the postal union, is Sixteen Shillings, payable in advance to the undersigned, J. L. E. DREYER. Post Office Orders to be made payable at the General Post Office, Dublin. Intending subscribers are requested to send in their subscription as soon as possible, in order that the number of copies to be printed may be known at once. No. I. will be published early in January.

We have already secured the co-operation of eminent men of science both at home and abroad. Thus the two first numbers will contain contributions from Lord Rosse, Lord Lindsay, Professor Klinkerfues, Professor Schjellerup, Dr. R. S. Ball, Dr. Börgen, and others. Papers written in French, German, or Italian will be printed in the original language (German MSS. are requested to be written in Roman characters).

RALPH COPELAND,
Observatory, Dunecht, Aberdeen.

J. L. E. DREYER,
Observatory, Dunsink, Co. Dublin.

SCIENCE:

A WEEKLY JOURNAL OF SCIENTIFIC PROGRESS.

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